EFFECT OF INTEGRATED FERTILIZATION AND COVER CROPPING ON N2O LOSSES IN AN IRRIGATED MEDITERRANEAN MAIZE FIELD

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Objectives

Agronomical and environmental benefits are associated with replacing winter fallow by cover crops (CC). Yet, the effect of this practice on nitrous oxide (N_2O) emissions remains poorly understood. The objective of this study was to evaluate the effect of two different CC species (barley and vetch) and fallow on N_2O emissions during the CC period and during the following maize cash crop period in an Integrated Soil Fertility management (ISFM) system. We also aimed to study the contribution of synthetic fertilizer and other N sources to N_2O emissions through a parallel ^{15}N labelled fertilizer experiment.

Method

The study was conducted at "La Chimenea" field station, located in the central Tajo river basin near Aranjuez (Madrid, Spain), where an experiment involving cover cropping systems and conservation tillage has been carried out since 2006. Soil at the field was a Typic Calcixerept with a silty clay loam texture and basic pH (8.2). The area has a Mediterranean semiarid climate, with a mean annual air temperature of 14 °C. Twelve plots (12m × 12m) were randomly distributed in four replications of three cover cropping treatments (seeded in October 2013), including a cereal and a legume: 1) barley (B) (*Hordeum vulgare* L., cv. Vanessa), 2) vetch (V) (*Vicia sativa* L., cv. Vereda), and 3) traditional winter fallow (F). The cover cropping phase finished on March 2014, with an application of glyphosate, and all the CC residues were left on top of the soil. Thereafter, a new set of N fertilizer treatments was set up for the maize cash crop phase. The fertilizer treatments consisted of ammonium nitrate (AN) applied on 2nd June at three rates: 170, 140 and 190 kg N ha^{-1} in F, V and B plots, respectively, according to ISFM practices. For the calculation of each N rate, the N available in the soil, the expected N uptake by maize crop, and the estimated N mineralized from V and B residues were taken into account. In order to determine the amount of N_2O derived from the N fertilizers, double-labelled AN ($^{15}NH_4{}^{15}NO_3$, 5 % atom ^{15}N) was applied on 2m x 2m subplots established within each plot at a rate of 130 kg N ha^{-1}. Nitrous oxide was sampled using opaque manual circular static chambers and measured by gas chromatography. Stable ^{15}N isotope analysis of N_2O contained in the gas samples was carried out on a trace gas analyzer (using cryo-trapping and cryo-focusing) coupled to a 20/22 isotope ratio mass spectrometer at Rothamsted Research North Wyke. Soil mineral N concentrations, soil temperature and moisture, dissolved organic carbon and GHG fluxes were also measured during the experiment.

Results

The ISFM resulted in low cumulative N_2O emissions (0.57 to 0.75 kg N_2O-N ha^{-1}) and N surplus (31 to 56 kg N ha^{-1}) for all treatments. The presence of CCs increased N_2O emissions during the intercrop period compared to F (1.6 and 2.6 times in B and V, respectively), but the intercrop period had a low impact in annual N_2O losses (8, 10 and 21% of total cumulative emissions in F, B and V, respectively). Average topsoil nitrate (NO_3^-) was significantly higher in V, which was the treatment that led to the highest N_2O emissions during this phase. Legumes such as V are capable of biologically fixing atmospheric N_2, thereby increasing soil NO_3^- content with potential to be denitrified.

The ISFM resulted in similar cumulative emissions for the CCs and F at the end of the maize cropping period. Barley-residue plots had higher N_2O emissions than fallow or V-residue plots (at the 10% significance level). The higher C:N ratio of the B residue led to higher DOC contents in these plots and a greater proportion of N_2O losses from the synthetic fertilizer in these plots, when compared to V. Taking into account the whole intercrop-maize cycle, the N_2O Emission Factor ranged from 0.2 to 0.6% of synthetic N applied,

which were lower than IPCC default value of 1%.

The replacement of bare fallow by CCs, in combination with an ISFM, did not increase soil N_2O emissions in the overall CC-cash-crop cycle. This fact should be taken into account since the potential of CCs to reduce indirect losses (through the abatement of NO_3^- leaching) and to increase C sequestration has been demonstrated in previous studies.

Conclusions

Our study confirmed that the presence of CCs (particularly V) during the intercrop period increased N_2O losses. Conversely, by employing ISFM, similar N_2O emissions were measured from CCs and F treatments at the end of the whole cropping period, with low N surpluses. Our results highlight the critical importance of the cash crop period on total N_2O emissions, and demonstrate that the use of either legume or non-legume CC combined with ISFM offers an opportunity for N_2O mitigation.